BULLETIN

OF THE

Society for the Promotion of Engineering Education

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EDITORIAL.

Engineering Coöperation.—In November will be held the first meeting of the American Association of Engineers. This brings into the engineering field one more organization, but its object is so different from that of the existing engineering societies that it seems worthy of support by all teachers of engineering.

The object, as stated in its first circular and sent under the direction of Professor F. H. Newell, of the University of Illinois, is a coöperative movement for the advancement of the general welfare of the engineers in North America, both individually and collectively, and is distinct from the more purely technical work now performed by existing engineering societies. The Society for the Promotion of Engineering Education is certainly interested in an organization of this character, since the economic and social welfare of teachers of engineering is the most important factor in securing the promotion of engineering education. It is proposed to utilize, as far as possible, the facilities which may be provided by the existing organizations, and at the same time help in building up the local engineering societies where none now exist. Its efforts will be directed along three lines, namely, diffusing information on engineering in general; collecting and diffusing facts concerning the employment of engineers; and collecting data regarding the legislation affecting engineers. By hearty coöperation between the Society for the Promotion of Engineering Education and this new organization we might well expect to promote, successfully, the economic welfare of teachers of engineering. This Society will be represented at the first annual meeting of the American Association of Engineers by a strong committee, the appointment of which will be shortly announced by President Jacoby.

THE MONTHLY LETTER.

It has been suggested that the Secretary write a letter each month to be published on this page of the BULLETIN, giving a brief outline of some of the work which is being carried on by the Society, and other matters of interest to the members.

Volume XXIII of the *Proceedings* was sent to the printer for paging about the first of October. The last of the page proof has just come from the printer and it is our expectation to have this volume mailed to members some time in November.

A small booklet giving the list of officers and members of the committees and the duties assigned each committee for the ensuing year was issued in July. A copy of this was sent to each member of the Society and many requested a number of extra copies. The edition was quickly exhausted and a second edition prepared, which contains considerable material pertaining to the Society, together with the material that was in the previous folder. A copy of this has been mailed to each member.

A membership campaign was started in September by securing from catalogs of engineering schools of the country, a list of those men who, by virtue of their positions, should be, but are not members of the Society, and sending them the information book, a letter inviting them to become members, and an application blank.

Fewer resignations than usual have so far been received in the Secretary's office. This is probably accounted for in part by the reorganization of the Society under the direction of committees whereby it is evident that the Society will be able to secure better results from its work. This is a most encouraging sign and stimulates the officers to attain greater benefits made possible by the larger membership.

The work of the different committees is well under way following a circular letter sent by the President to the chairmen

of the different committees. We may look for some very interesting and important reports by the various committees at the next annual meeting.

INAUGURATION OF JOHN HENRY MACCRACKEN.

A notable event in the educational world was the Inauguration on October 20 of John Henry MacCracken, LL.D., as ninth president of Lafayette College. The program opened on the afternoon of the 19th with an educational conference in which the educational problems of Lafayette were discussed. In the evening a reception, followed by a dinner, was given by the Board of Trustees to the delegates, alumni and guests. The interest and loyalty of the student body were well demonstrated in the rousing torchlight parade in which some 600 students, many in fanciful costumes, marched down through the city to the Hotel Karldon and with cheers and songs called forth the new president. About 350 guests sat down to the dinner. Notable responses to toasts were made by President John Grier Hibben, of Princeton University, President John Huston Finley, of the University of the State of New York, Dr. George Morris Philips, principal of the West Chester Normal School, President Harry B. Hutchins, of the University of Michigan, President Ethelbert T. Warfield, of Wilson College, and former president of Lafayette College, Vice-President Natt M. Emery, of Lehigh University, Chancellor S. B. McCormick, of the University of Pittsburgh, and Chancellor Charles Alexander Richmond, of Union University.

The inaugural exercises proper began at 9:30 the next morning in the auditorium of Pardee Hall with the individual presentation of the delegates to the new president and the vice-president of the board of trustees. About 137 universities, colleges, and learned societies were represented. An address of welcome by Professor Francis A. March, Jr., of Lafayette College was responded to on behalf of the delegates

by President Charles F. Thwing of Western Reserve University. On account of rain the academic procession from College Chapel to Pardee Hall had to be given up.

The inaugural exercises were held in the latter place at 11:00 A. M., Mr. Israel P. Pardee, president of the board of trustees, presiding. President MacCracken chose for the subject of his inaugural address, "College and Commonwealth." He sounded a reactive note of warning against a tendency in modern education. "The first service of the college is to teach. That, you think, goes without saying, but does it? By teaching I do not mean training, drawing forth of innate power, the development of character, the stimulation of ambition, but by teaching I mean just what it means in the primary school, imparting to the student, in such a way that it becomes a permanent possession, a knowledge of truth and things, a knowledge also of causes and of values. I find a great deal of skepticism as to the value of this part of the colleges' work. Do we Americans generally prize very highly the knowledge which the college curriculum purports to impart? Do we not rather all agree that the majority of college students do not know five years after graduation what they gave sufficient evidences of knowing to pass the college examinations?" In engineering education there has been a decided reaction away from purely informational courses and rightly so. Yet engineering is more than mental capacity. It is exact knowledge, even if, for the undergraduate, such knowledge does not go beyond fundamental principle.

Following the closing address by Judge E. H. Gary, chairman of the United States Steel Corporation, honorary degrees were conferred as follows: The honorary degree of Doctor of Letters was conferred upon Martin Grove Brumbaugh, Governor of Pennsylvania; Ernest Gottlieb Sihler, Professor of Latin in New York University; Ethelbert Dudley Warfield, President of Wilson College. The honorary degree of Doctor of Science was conferred upon Frank Henry Constant, professor of civil engineering in Princeton University; Henry

Fay, professor of analytical chemistry in the Massachusetts Institute of Technology; Richard Mills Pearce, Jr., professor of research medicine in the University of Pennsylvania; George Joseph Ray, chief engineer of the D. L. & W. R. R. The honorary degree of Doctor of Laws was conferred upon Francis Shunk Brown, attorney-general of Pennsylvania; Winston Churchill, author; Thomas DeWitt Cuyler, lawyer; Elbert Henry Gary, chairman of the United States Steel Corporation; Edward Kidder Graham, president of the University of North Carolina; Thomas Hastings, architect; Albert Ross Hill, president of the University of Missouri; Cyrus Hall McCormick, president of the International Harvester Company; Robert Mackenzie, secretary of the college board of the Presbyterian Church; John C. Sharpe, head master of Blair Academy; Joseph Ross Stevenson, president of Princeton Theological Seminary; Oswald Garrison Villard, president of the *New York Evening Post.* After the inaugural exercises a delightful luncheon was served by the ladies of Easton and Phillipsbusg, with President MacCracken presiding. Toasts were responded to on behalf of the newly honored alumni of Lafayette College by Doctors Cyrus Hall McCormick, Edward Kidder Graham, Richard Mills Pearce, Jr., Albert Ross Hill, Winston Churchill, and Governor Martin Grove Brumbaugh.

A football game between Lafayette and Delaware State College on March Field, to which the guests were invited, closed what has not only been a momentous event in the history of Lafayette College but what will long be remembered as a notable inaugural in the annals of American colleges. The long elaborate program of events passed off with dignity, precision and celerity.

John Henry MacCracken graduated from New York University in 1894, and later studied at the University of Wittenberg, Germany, receiving degrees from both universities. He was a member of the faculty of the New York University, became president of the Westminster University in 1899 and

in 1903 he returned to New York University to fill the position of syndic. He comes from a remarkable family of college presidents, his father having been for many years Chancellor of New York University, and his brother, Dr. Henry Noble MacCracken, having recently been inducted into the office of president of Vassar College.

His ripe scholarship, his experience in college administration, his broad sympathies, his enthusiastic energy, and his charming personality form a rare combination of qualifications for the high post he is called to fill as the head of an old and honored institution. The multitude of friends of Lafayette wish her well and congratulate her upon the auspicious beginning of the new era of development and service which is ahead of her.

COUNCIL ACTIONS.

The Council has just elected, by letter ballot, eighteen individual members and one institutional member. The names of these new members will be found on another page of this number.

SOCIETY NOTES.

At the request of Professor C. F. Scott, chairman of the Committee on Electrical Engineering, Mr. A. L. Rohrer was transferred from the Committee on Administration to the Committee on Electrical Engineering. Professor G. C. Whipple has been appointed to succeed Mr. Rohrer on the Committee on Administration.

A letter ballot to determine the time of meeting and also the place of meeting for 1916 is now under way. To date the returns have not been such that the result can be published. We expect, however, to be able to publish in the next number of the BULLETIN the time and place of meeting for 1916.

The Society has received an invitation from the Association of Urban Universities to send representatives to a conference on coöperation between the university and the city in training for public service, to be held at the University of Cincinnati November 15–17. President Jacoby has asked Dean A. S. Langsdorf of Washington University and Dean A. R. Cullimore of Toledo University, in addition to the Secretary, to represent the Society at this conference.

LETTERS TO THE EDITOR.

The following letter which was received by Professor Edgar Marburg and forwarded to the Secretary, is of interest to the members of the Society because of the indication which it gives of the awakening of interest in American texts shown by our Southern neighbors:

September 18, 1915.

Dear Sir: As American books are very little known here, we have thought that the professors of American universities could do us a great favor informing us about good books for the study of the different subjects comprised in the engineering profession (civil, electrical, and mechanical) and for the practice of said profession.

Please be so kind as to answer this card, and oblige

Yours very truly,

(signed) RAMIRO PINOCHET.

SAN BERNARDO, CHILE.

TO THE EDITOR.

Dear Sir: The faculty of the School of Engineering of the University of Missouri held a called meeting recently for the purpose of listening to reports of the Ames meeting of the Society. The faculty meeting was attended by practically every technical member.

Professor F. P. Spalding made the principal report, giving his impressions of the various papers and the social features

of the meeting. This was followed by a supplementary report by Dean McCaustland.

After these reports were heard, the meeting resolved itself into a forum for very free discussion not only upon the reports but also on some other items of educational policy suggested by the reports of the papers at the Ames meeting.

The meeting adjourned at a late hour, and remarks made by many of the members indicated a feeling that this meeting and the discussion brought out were very much worth while.

I do not know whether this practice is followed elsewhere but it seems to be an excellent means for getting the activities of the Society before those engineering teachers who are unable to attend the Society meetings.

E. A. FESSENDEN.

NEW MEMBERS.

AYDELOTTE, FRANK, Professor of English, Massachusetts Institute of Technology, Boston, Mass.

ENGEL, GODFREY, Engineer of Construction, American Sugar Refining Co. of N. Y., Brooklyn, N. Y.

ENSIGN, N. E., Associate in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

ETHERTON, W. A., Professor of Rural Architecture, Kansas State Agricultural College, Manhattan, Kans.

FETTER, F. A., Professor of Economics, Princeton University, Princeton, N. J.

GLASS, R. L., Instructor in Electrical Engineering, University of Pittsburgh, Pittsburgh, [illegible].

HALLOCK, J. W. W., Instructor in Charge, Co-Operative Work, University of Pittsburgh, Pittsburgh, Pa.

HENDRY, W. S., Instructor in Mechanic Arts, University of Arizona, Tucson, Ariz.

MCLEOD, D. F., Assistant Professor of Civil Engineering, University of of Mississippi, University, Miss.

OGLESBY, E. J., Instructor in Mathematics, University of Virginia, University, Va.

PATTERSON, L. L., Professor of Electrical Engineering, Mississippi A. & M. College, Agricultural College, Miss.

PORTER, H. E., Assistant Professor of Mathematics, Kansas State Agricultural College, Manhattan, Kans.

PRATT, H. B., Test Engineer, Public Service Commission, Harrisburg, Pa.

REED, K. W., Principal of the Apprentice School, The Warner & Swasey Co., Cleveland, Ohio.

SANDERS, W. H., Instructor in Farm Motors, Kansas State Agricultural College, Manhattan, Kans.

SCARBOROUGH, J. B., Instructor in Mathematics, North Carolina A. & M., College, Raleigh, N. C.

TYLER, H. G., Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

WIGLEY, W. R., Instructor in Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa.

CRANE TECHNICAL HIGH SCHOOL AND JUNIOR COLLEGE, Chicago, Ill., Wm. J. Bartholf, Principal.

APPLICANTS FOR MEMBERSHIP.

COX, J. J., Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich.

DIEDERICHS, HERMAN, Professor of Experimental Engineering, Cornell University, Ithaca, N. Y.

KIMBALL, D. S., Professor of Machine Design and Industrial Engineering, Cornell University, Ithaca, N. Y.

LANIER, A. C., Professor of Electrical Engineering, University of Missouri, Columbia, Mo.

MOORE, F. C., Associate Professor of Mathematics, New Hampshire College of A. & M. Arts, Durham, N. H.

BOOKS RECEIVED.

Mathematical Tables for Class Room Use. By MANSFIELD MERRIMAN. Published by John Wiley & Sons, Inc. 1915. Cloth, 50 cents net.

Elements of Railroad Track and Construction. By WINTER L. WILSON. Published by John Wiley & Sons, Inc. 1915. Cloth, $2.50 net.

Field Engineering. By WM. H. SEARLES AND HOWARD C. IVES. Published by John Wiley & Sons, Inc. 1915. Leather, $3.00 net.

Handbook of Mathematics for Engineers. By L. A. Waterbury. Published by John Wiley & Sons, Inc. 1915. Leather, $1.50 net.

Machine Design. By Albert W. Smith and Guido H. Marx. Published by John Wiley & Sons, Inc. 1915. 6 by 9, cloth, $3.00 net.

Agricultural Drawing and the Design of Farm Structures. By Thos. E. French and Fred. W. Ives. Published by McGraw-Hill Book Co., Inc. 1915. Cloth, $1.25 net.

BOOK REVIEWS.

Mathematics for Agricultural Students. By Henry C. Wolff, Ph.D., assistant professor of mathematics, University of Wisconsin. McGraw-Hill Book Company, New York, 1914. Pp. vii + 309.

This text contains selected portions of algebra, trigonometry and analytic geometry. It also includes a brief discussion of the slide rule, theory of errors, and empirical equations.

The author states in the preface that the book is not intended as a text of advanced algebra, trigonometry, or analytic geometry. He believes that a student pursuing a scientific course receives little profit from formal courses in these subjects.

In this book the author aims to "develop in the student the habit of careful and logical thinking" and by means of illustrations and exercises "shows the student how mathematics may be helpful in pursuing other subjects of study."

One who has taught scientific students, especially agricultural students, freshman mathematics as required work knows how difficult it is to train them in careful and logical thinking and to show them how mathematics may be helpful in pursuing other subjects of study. In writing this text Dr. Wolff has taken a step in the direction of lessening these difficulties. The text will prove an aid in developing a scientific method of thought and there are enough problems based upon

scientific data to suggest, at least, the possibility of the usefulness of mathematics in other scientific subjects.

In the words of the author, "With the exception of the illustrations and exercises, the book contains nothing which is of exclusive interest to agricultural students. It may be used equally well with any class of scientific students who desire only a short course in mathematics beyond elementary algebra and geometry." Had the author used the few illustrations which have agricultural settings as problems and introduced illustrations of a general scientific nature in their stead the text would have fulfilled its present mission and at the same time made a stronger appeal to the general scientific student.

L. C. PLANT.

Electrical Engineering, Vol. I, Introductory. By T. C. BAILLIE, principal of the Croydon Polytechnic Institute. Cambridge University Press. 1915. 236 pages, illustrated. Cloth 5½ x 9. Price 5s. net.

This is a text-book for elementary courses in electrical engineering presenting particularly the fundamental principles. It is an excellent book for laboratory reference in the accurate measurements of current, electromotive force and resistance. It includes a detailed description of potentiometer methods of electrical measurements not usually found in an elementary text of this kind.

H. E. D.

The Electric Railway. By MORRIS BUCK, assistant professor of railway electrical engineering, University of Illinois. McGraw-Hill Book Co. 1915. 6 x 9 cloth. 390 pages, illustrated. Price $3.00

A text-book in electrical railways for advanced students in technical schools who are specializing in electric traction. The subject matter in each chapter is complete in itself, making it possible to rearrange or omit chapters as the instructor may desire. Chapters on power plant, transmission lines, and car equipment are omitted. This has permitted the author to give a more complete development of the funda-

mental principles of electric railway design and operation than is usually found in a text-book of this size.

H. E. D.

COLLEGE NOTES.

Colorado School of Mines.—Mr. James Cole Roberts of the United States Bureau of Mines, Denver, Colorado, has been elected to the Joseph Austin Holmes Professorship of Safety and Efficiency Engineering. Mr. Roberts will assume his duties November first.

University of Illinois.—The number of students registered in the College of Engineering ten days after the beginning of the registration for the new year, is as follows: Freshmen, 326; Sophomores, 302; Juniors, 299; Seniors, 253; Specials, 4, making a total of 1184 students. This statement does not include the number of Engineering students registered in the Graduate School.

The corner-stone of the Ceramic Engineering Building was laid on Monday, September 27, 1915. Among the speakers on this occasion were Professor Edward Orton, Jr., Dean of the College of Engineering of The Ohio State University and Mr. Wm. D. Gates, President of the American Terra Cotta and Ceramic Company, Chicago, Ill., representing the Advisory Board for the Department of Ceramic Engineering.

Massachusetts Institute of Technology.—At a recent meeting of the corporation the following appointments were confirmed: R. M. Frye, instructor in Physics; R. W. Porter, instructor in design; H. W. Brown, assistant in mechanical engineering; C. H. Calder, H. W. Lamson, and J. C. McKinnon, assistants in Physics; T. H. Huff, assistant in aeronautical engineering; G. W. Simons, Jr., H. C. Thomas, and A. N. Wardle, assistants in civil engineering; E. E. Snyder, Jr., assistant in industrial chemistry; R. Eksergian and Leon H. Webber, research assistants in electrical engineering.

In addition to these appointments confirmed, the executive

committee announces the appointment of the following to the instructing staff, the confirmation coming at a later meeting of the corporation: John Hyneman, P. J. Munn, and E. S. Tisdale, assistants in civil engineering; A. R. Greenleaf, assistant in Physics; F. L. Hunt, instructor in Physics; V. C. Kennedy, and H. N. Carlson, assistant in electrical engineering, and A. S. Dana, previously appointed research assistant in electrical engineering, who is to be part time assistant in the course on alternating currents.

University of Michigan.—John C. Parker has been appointed head of the electrical engineering department, vice Professor G. W. Patterson who is transferred to the department of engineering mechanics. Professor Parker comes to Michigan from Rochester, N. Y., where he has, for a number of years, been chief mechanical and electrical engineer for the Rochester Railway and Light Co.

Dr. Karl E. Guthe, professor of physics and dean of the graduate school, died suddenly at Ashland, Ore., while on a trip to the Pacific coast. Professor A. H. Lloyd has been appointed dean of the graduate school to fill the vacancy caused by the death of Professor Guthe. Professor Lloyd has been a member of the Michigan faculty since 1891.

Professor John R. Allen has been appointed consulting engineer for the Treasure State Mineral Co., Butte, Mont. He made a personal inspection of the property in September.

Professor James P. Bird, for a number of years secretary of the college of engineering, resigned to become head of the department of Romance languages at Carleton College.

The old power house has been fitted up as laboratories for the automobile and highway engineering departments. The enrollment in the college of engineering shows a gain over last year.

University of Minnesota.—The work of Assistant Professor Franklin R. McMillan on "Shrinkage and Time Effects in Concrete" has attracted considerable attention. The path breaking nature of this important work is being widely rec-

ognized by the technical press and by practicing engineers.

University of North Dakota.—Professor A. J. Becker has returned from a year's leave of absence and has again taken up his work as professor of applied mathematics. While on leave he completed the required work for the degree of Doctor of Philosophy at the University of Illinois, receiving the degree last June.

Prior to July, 1915, the State University and each of the other educational institutions, charitable institutions excepted, had its own board of regents which controlled and directed the work of the institution, but beginning with July 15, 1915, all of the state educational institutions, charitable institutions excepted, will be under the control of one Board of Regents, consisting of five members who are appointed by the Governor and confirmed by the State Senate.

The members of the Board will receive $7.00 per day, and necessary traveling expenses while attending meetings, etc. The Board is authorized to elect a secretary who shall receive a salary not to exceed $2,500 per annum.

Pennsylvania State College.—The publication of the book by Professor A. J. Wood on "Principles of Locomotive Operation and Train Control" has been announced for November. "Engineering Thermodynamics," by Professors J. A. Moyer and J. P. Calderwood, will be published the latter part of October.

Professor J. A. Moyer, head of the department of mechanical engineering, has been appointed director of the university extension in Massachusetts. This appointment was made by the Board of Education in September and approved by Governor Walsh on October 13. Professor Moyer's department is a new one and will have $50,000 at its disposal for the first year. This department will occupy one floor of the new state house extension as soon as it is completed. Professor Moyer is considered one of the best equipped men in the country for the position to which he has just been appointed.

Mr. A. H. Spahr, instructor in engineering extension, has

resigned to become professor of physics in the Kansas State Normal College, Pittsburgh, Kans. Mr. N. C. Miller, who last semester had charge of the extension classes in the eastern part of the state, will be located at State College this year as instructor in Mechanical Engineering, and Mr. C. F. Kopp, of Amite, La., will take up his work. Mr. Miller organized classes for the employees of the Philadelphia and Reading Railroad at Reading, and for the Ridgway Dynamo and Engine Company at Ridgway.

A most interesting and pleasing part of the work of last year was the commencement exercises at the Allentown school at which 174 students received diplomas. Owing to the large number present three rooms were used, thus making it necessary for each speaker to deliver his speech three times. At the conclusion of the exercises the instructors and speakers were presented with gifts from the students. Ex-Representative Miller presented President E. E. Sparks, Professor J. A. Moyer, and to those of the trustees who were present, neckties made from silk woven by the students in textile engineering. That this school has aroused more than local interest is shown by the fact that one of the recent requests for information concerning it came from a fiber expert in Honolulu. A floor of one of the school houses has been remodeled and equipped with the necessary machinery for the classes of this extension school at a cost of $3,000. These rooms will be formally opened on October 29.

Princeton University.—Mr. H. B. Dirks (Ill. B.S. 1904, M.E. 1905) has been appointed an instructor in the mechanical subjects of the civil engineering department. Mr. George E. Beggs has been advanced from the grade of instructor to that of assistant professor of civil engineering. Mr. J. W. Aymar, Jr., has been transferred from the graphics department to be instructor in geodesy. Professor Beggs has completed a new text-book on "Live Load Stresses in Railway Bridges" which is now in press with Wiley & Sons and will appear in December.

Aside from the graduate department in electrical engineering, Princeton has but one engineering course, that in civil engineering. Some radical changes in the civil engineering curriculum have been put into effect this year, however, aiming to produce a rather general course in engineering. A high degree of specialization in any one field is avoided. In consequence, both mechanical and electrical engineering receive more attention than formerly. A year course under Professor Fetter in the fundamental principles of economics has been introduced in the junior year. The work in English in the freshman year, while still maintaining some of its literary character, has been increased to include the principles and practice in technical writing. A year course in English has also been introduced in the senior year, designed to give practice in public speaking, in preparing clear, well written reports, and in explaining or defending them in public. The enrollment in the freshman class has increased from 36 in 1914–15 to 43 for the present year.

Throop College of Technology.—The College opened September 18 with an enrollment much increased over last year, the fall registration being 126 as against a total registration for last year of 91. A feature of the new year is the opening of the first dormitory on the campus, with accommodations for about sixty students.

The most important development during the summer, formal announcement of which was made at the opening of the college year, was the gift by two anonymous donors of $60,000 for the erection of a chemistry building. This is pursuant to the plan by which Dr. Arthur A. Noyes, of the Massachusetts Institute of Technology, will henceforth be connected with the faculty of Throop College, giving a portion of his time there during the coming academic year, and one half of each year beginning with 1916–1917. Funds have been provided for the equipment of a research laboratory for him in the new chemistry building, and a special endowment provides for its permanent maintenance. The chemistry

building will be completed and ready for occupancy in September, 1916.

New appointments to the staff of instruction are Seward C. Simons, A.B. Harvard, 1911, associate professor of economics and history; Frederick C. Kennedy, B.S. Massachusetts Institute of Technology, 1914, instructor in mathematics and drawing; Alexander Enenkel, instructor in modern languages; and Robert S. Ferguson, B.S. Throop, 1915, tutor in mathematics and assistant in electrical engineering.

University of Virginia.—The ninety-first continuous session of the university opened on September 16 with a notable increase in attendance, particularly in the college and in engineering. For the first time in the history of the institution, the registration has reached the thousand mark, and this notwithstanding the drastic raising of standards of admission during the past few years.

Plans are being drawn for the new chemical laboratory, which is to cost upward of $100,000.

Radical extensions to the equipment of the medical school are contemplated before next session in order to accommodate the increasing number of applicants for entrance to that department. It has been found necessary to refuse entrance in the medical school to some thirty men this session for lack of equipment necessary to maintain the high grade of instruction at present secured.

A new athletic building to cost $50,000 will be erected in the spring for the accommodation of the home and visiting teams.

Dr. J. S. Grasty, of the school of geology, spent several weeks the past summer in the Coeur d'Alene mining district of Idaho, representing certain mining interests holding properties there.

"Engineering Geology," of which Dr. T. L. Watson, of the School of Geology, is a co-author, has proven so popular as a text that the third printing in less than one year has been found necessary.

THE CONSERVATION OF ENERGY.

A PLEA FOR THE LANGUAGE OF EXPERIMENT IN THE TEACHING OF PHYSICS.

BY W. S. FRANKLIN AND BARRY MACNUTT.

One of the broad generalizations of physics is the principle of the conservation of energy, and the usual statement of the principle is that energy can neither be created nor destroyed. It is very desirable, however, to state a physical principle so as to suggest trial and verification. Tell a woman that she cannot drive a nail and she will, if she takes you seriously, get hammer and nail and try! When Tom Sawyer tells his playmates that they cannot whitewash a fence they are all eagerness to submit the proposition to an experimental test! But what young man ever dreamed of trial and verification when told that energy can neither be created nor destroyed! Indeed the statement does not suggest any physical operation whatever, it is actually meaningless unless one knows beforehand what its meaning is intended to be. Let us therefore look into the matter from the purely mechanical point of view, all heat effects being ignored.

Consider a purely mechanical system (the earth and a weight, for example) in a *given configuration.* The potential energy of the system may be defined as the work done by the forces in the system when the system is brought back from the given configuration to an arbitrarily chosen *zero configuration.* Let us consider what changes this work would produce in the system on the assumption that no outside forces act and on the assumption that there is no friction or collision or other action which might bring about heat effects. Under these assumed conditions it can be shown by argument based on the definitions of work and kinetic energy and on Newton's laws of motion that the work above mentioned (the decrease of the

potential energy of the system) all goes to increase the kinetic energy of the system and is equal to this increase. Therefore, if our definition of potential energy is legitimate, any change of a purely mechanical system which represents a decrease of the potential energy of the system must be accompanied by an equal increase of the kinetic energy of the system, and *vice versa,* when no outside forces act on the system. Therefore the sum of the potential and kinetic energies of such a system must remain constant, that is, the principle of the conservation of energy must be true of such a system if our definition of potential energy is legitimate.

But our definition of potential energy is not legitimate until we have become convinced by experiment that *the amount of work done by the internal forces of a system while the system is changing from one configuration to another is always the same whatever the intermediate stages may be through which the system passes in being brought from one configuration to the other.* If this were not true it would be absurd to speak of the potential energy of the system in a given configuration. Indeed this statement, which justifies the idea of potential energy, is the essence of the principle of the conservation of energy in its purely mechanical sense. That is, when reduced to its simplest terms, the principle of the conservation of energy is that *you cannot get more work out of a system by letting it down, as it were, from condition A to condition B than must be done to carry the system back from B to A.*

Take a stone and lower it from a high position *A* to a low position *B,* thus getting work or energy out of it; then bring the stone back from *B* to *A,* slipping it behind your back in the hope or pretense of getting it back to *A* with a small expenditure of work! This procedure strongly suggests the point of view of every perpetual-motion promoter, namely, a vague and wholly unintelligent expectation of success or downright cheating!

The extension of the principle of the conservation of energy so as to cover heat effects (including all chemical effects) is called the first law of thermodynamics, and stated in the lan-

guage of experiment, it is as follows: *A certain change of state is produced in a substance A by the dissipation of work, and the substance A is brought back to its initial condition by contact with another cooler substance B; then the change produced in B is exactly the same as if the original work had been expended (dissipated) on B directly.* How much more intelligible this statement than any abstract statement concerning the equivalence of work and heat, especially if such a statement is made (as it usually is) before heat is defined as a measurable quantity! Indeed the above statement *is* the definition of heat as a measurable quantity, but merely as such it can be stated in a simpler form.

THE SECOND LAW OF THERMODYNAMICS.

BY W. S. FRANKLIN AND BARRY MACNUTT.

In the previous paper we discussed the principle of the conservation of energy to illustrate the appeal to sense which comes from the use of the language of experiment; and the object of this paper is to illustrate the value of a suggestive appeal to general experience in the discussion of the principles of physics. The second law of thermodynamics is best suited to our present purpose because no other generalization in physics is based upon such deeply seated intuitions and such widely diffused experience.

It is a familiar fact that a substance or a system of substances settles to a quiescent state when left to itself and shielded from all outside disturbing influences. Such a quiescent state is called a state of *thermal equilibrium,* and two substances which have settled to a common state of thermal equilibrium are said to have the *same temperature.* Thus a number of bodies left together in a closed room settle to a common temperature, and when a piece of red hot iron is thrown into a pail of water the mixture is at first violently turbulent but it soon settles to thermal equilibrium.

Consider the successive stages of the change which takes place while a system of substances is settling to thermal equilibrium, for example, consider the successive stages of the change which takes place when a piece of red hot iron is dropped into a pail of water, and imagine these stages to follow each other *in a reverse order* after the iron has cooled off. If such a thing could be it would mean that the piece of iron would become red hot again and jump out of the pail. No one ever saw such a thing happen, and the postulate that such a thing never can happen is called the *second law of thermodynamics.*

The bald statement that a piece of iron lying quietly in a pail of water cannot become red hot spontaneously and jump out of the pail carries with it no general idea, and to say that "nothing of the kind" can take place is too vague to convey any meaning at all. Therefore it is evident that a general statement of the second law of thermodynamics cannot be made until we have developed a point of view which will permit us to speak intelligibly and definitely, but in general terms, of all kinds of spontaneous action.

Reversible Processes.

A substance in thermal equilibrium is generally under the influence of external agencies. Thus surrounding substances confine a given substance to a certain region of space, and they exert on the substance a definite pressure; surrounding substances are at the same temperature as the given substance; surrounding substances may exert constant electric or magnetic influences on the given substance; and so on. If the temperature of the surrounding substances be raised or lowered very slowly, or if the influences they exert upon the given substance be made to change very slowly, *then the given substance will pass through a continuous series of states of thermal equilibrium;* such a slow change of the substance is called a *reversible process* because the substance will pass through the same series of states in a reverse order if the external influences are changed slowly in a reversed sense.

Irreversible Processes or Sweeps.

When a substance is settling or tending to settle to thermal equilibrium it may be said to undergo a process. Such a process cannot be arrested or held at any stage short of complete thermal equilibrium, but it always and inevitably proceeds towards that state. Such a process may therefore be called a *sweeping process* or simply a *sweep.*

A *simple sweep* is the settling of a closed system to thermal equilibrium. For example, the equilibrium of a batch of gun

powder in a large room may be disturbed by ignition, and the explosion of the powder and the subsequent settling of the residual gases to a quiescent state constitute a simple sweep. The equilibrium of a gas confined under high pressure in one compartment of a two-compartment vessel may be disturbed by opening a cock which connects the two chambers, and the rush of gas through the opening and the subsequent settling of the gas in both chambers to a state of thermal equilibrium constitute a simple sweep.

Trailing sweep. When external influences change continuously and rapidly, a substance is all the time settling towards thermal equilibrium and it never catches up with the changing influences, but trails along behind them as it were, and there exists what may be called a trailing sweep. Thus the rapid heating of water in a tea kettle is a trailing sweep; the bottom of the kettle is always a little hotter than the water.

Steady sweep. A substance may be subject to external action which, although permanent or unvarying, is incompatible with thermal equilibrium. Under such conditions the substance settles to a permanent or unvarying state which is not a state of thermal equilibrium. Such a permanent state of a substance may be called a steady sweep. For example, the two faces of a slab or the two ends of a rod may be kept permanently at different temperatures, and when this is done the slab or rod settles to a permanent or unvarying state. Heat flows through the slab or along the rod from the region of high temperature to the region of low temperature, and this flow of heat is an irreversible process. The ends of a wire may be connected to the terminals of a battery or dynamo so that a constant electric current flows through the wire, and the heat which is generated in the wire by the electric current may be steadily carried away by a stream of water or air. Under these conditions the wire settles to an unvarying state which is by no means a state of thermal equilibrium; the battery or dynamo does work steadily on the wire and this work reappears steadily in the wire as heat.

Descriptive Science and Statistical Science.

The greater part of physical science as applied in the arts and as used by the investigator is essentially descriptive. Thus we may wish to determine how the members of a bridge stretch or shorten as a car passes across the bridge; how electromotive force, current strength and all the changing variables play in the operation of a dynamo; how the pressure and temperature of the steam vary during the successive stages of admission, expansion and exhaust of a steam engine; and so on. But everything that takes place in this world has associated with it a substratum of complex action which baffles description. Consider, for example, a simple thing like the movement of a train of cars. The engineer is concerned only with certain broad features of what takes place, the amount of coal and water used, the draw-bar pull of the locomotive, and the forward motion of the cars as affected by steepness of grade, and the opposing force of friction. But who could describe in detail the rocking and rattling motion of the cars and the whirling and eddying motion of the surrounding air, and who could trace the motion of every particle of dust and smoke! This indescribably complex action we call by the name of *turbulence*,—it exists everywhere and in everything that goes forward in this world of ours, and it is never twice alike in detail even when the conditions are what one would consider exactly the same. All of which suggests two postulates concerning turbulence, namely (*a*) That it is infinitely* complicated, and (*b*) That it is essentially erratic in character. Let it be understood, however, that we are not speaking in terms of ordinary values in making these two statements. It is not a question, for example, as to whether a brakeman loses his hat every time he makes a trip from Albany to Buffalo, but it is a question as to whether his hat is lost every time at identically the same place because of a gust of wind of pre-

* The idea of infinity which comes from counting, one, two, three, four, and so on *ad infinitum*, is as nothing compared with the intimation of infinity that comes from things that are seen and felt!

cisely the same character when he lets go of it in the same way because of a sudden jerk of the train which always occurs at the same place in exactly the same manner, and so on in endless detail of specification—if such specification were possible!

In the motion of a simple mechanism like the sun and planets, or in the operation of a simple machine like a dynamo the accompanying erratic action is practically negligible. Thus one does not consider even the tremendous storm movements in the sun in the study of planetary motion, and one does not consider the minute details of the motion which takes place in a lubricated bearing in the study of the operation of a dynamo. In many phenomena, however, erratic action is dominant, and in the study of such phenomena the statistical method is used. The best example of this class of phenomena is weather phenomena. Consider the motion of the water in a brook. This motion presents a fairly definite average character at each point, and a fairly typical rhythmic variation from this average exists at each point, but there is an erratic departure from this regular motion which is by no means negligible in magnitude. So it is, in the case of the weather. There is a fairly definite average of weather conditions at a place from year to year, and a fairly typical rhythmic variation, but there is an erratic departure from average and from type, and this erratic variation of the weather can only be studied statistically.

Thermodynamic Degeneration.

A further consideration of the characteristics of sweeping processes will be helpful. The most familiar example of such a process is ordinary fire, and, as everyone knows, a fire is not dependent upon an external driving cause, but when once started it goes forward of itself and with a rush. It is not exactly correct to speak of a fire as *spontaneous* because this word refers especially to the beginning of a process, whereas, we are here concerned with the characteristics of a process already begun. Therefore it is better to describe a phenom-

enon like fire as *impetuous* because it does go forward of itself. Tyndall, in referring to the impetuous character of fire, says that it was one of the philosophical difficulties of the eighteenth century. A spark is sufficient to start a conflagration, and the effect would seem to be out of all proportion greater than the cause. Herein lay the philosophical difficulty. This difficulty may seem to be the same as that which the biologist faces in thinking of the small beginnings of such a tremendous thing as the chestnut tree blight in the United States. The chance importation of a spore is indeed a small thing, but it is by no means an infinitesimal, whereas, under conceivable conditions a fire can be started by a cause more minute and more nearly insignificant than anything assignable. This possibility of the growth of tremendous consequences out of a cause which has the mathematical character of an infinitesimal is the remarkable thing; and this possibility is not only characteristic of fire but it is characteristic of impetuous processes in general.

Everyone has a sense of the irretrievable aspects of a disaster such as the collapse of a bridge, or the wreck of a ship, or the destruction of a house by fire; and although such things may be forgotten after reconstruction, the fact remains that the destruction is absolute, it cannot be undone. Also everyone has a sense of the extreme complexity of detail of every disaster. Imagine anyone making the attempt to study the minute details of a conflagration, recording the height and breadth and the irregular and evanescent distribution of temperature throughout each flicker of consuming flame, the story of each crackling sound and the extent and character of every sway of timber and wall! And consider how utterly useless and uninteresting such a record would be even if it could be made! From a practical point of view the important thing in the collapse of a bridge or the wreck of a ship or the destruction of a house by fire is the money* loss involved, and money

* Other than money values are here ignored for the sake of simplicity.

loss is the only basis upon which one disaster can be definitely compared with another.

When a charge of gunpowder is exploded in a large empty vessel, everything remains after the explosion; all of the material is there and all of the energy is there. And yet the powder cannot be exploded a second time! You cannot burn your coal twice; and your cake, you cannot eat it and have it! The explosion of gunpowder, and the burning of coal, and the utilization of food in the body are what we have called sweeping processes, in detail they are infinitely complicated, and it is not only impossible to compare two sweeping processes detail by detail but it would be useless even if it could be done. However, the impetuous character of a sweeping process suggests a certain havoc, a certain *degeneration,* in the substance or substances in which the sweep takes place, and if we can establish this idea of thermodynamic degeneration as a definitely measurable quantity we will have a basis for the comparison of any two sweeping processes, namely, in terms of the thermodynamic degeneration involved in each. Such a quantity does in fact exist, and it is usually called *increase of entropy.*

To establish the idea of thermodynamic degeneration it is necessary to begin with the *assumption* that every sweeping process does involve a definite amount of thermodynamic degeneration, then derive by strict argument the physical consequences which necessarily follow from the assumption, and subject these consequences to the test of experiment. This program is much too extensive for a brief article, and we therefore attempt to do little more than make the nature and scope of the assumption clear.

In a simple sweep the degeneration lies wholly in the relation between the initial and final state of the substance which undergoes the sweep. This must be true because no outside substance is affected in any way by a simple sweep, no work is done on or by the substance which undergoes the sweep and

no heat is given to or taken from it. In a trailing sweep the degeneration may lie partly in the relation between the initial and final states of the substance which undergoes the sweep and partly in the change which takes place in outside substances. In a steady sweep, however, it is possible to think of the degeneration as lying wholly in the conversion of work into heat or in the flow of heat from a high temperature region to a low temperature region, or both; because the substance which undergoes the sweep remains entirely unaltered.* Therefore the idea of thermodynamic degeneration as a measurable quantity can be reached in the simplest possible manner by a careful consideration of a steady sweep. In speaking of the havoc which is wrought by a sweeping process we have had in mind the impetuous character of such a process, and to consider so mild a thing as a steady sweep may seem to be a weakening of our argument; but the initial steps of any physical argument should have a vivid appeal to sense. It is for this reason that we have directed the reader's attention to the quick and spectacular process of burning rather than to the slow and invisible process of rotting, although it is in the end as bad to lose a house by rotting as it is to lose a house by the quick calamity of a conflagration.

PROPOSITION. *The thermodynamic degeneration which is involved in the direct† conversion of work into heat at a given temperature is proportional to the quantity of work so converted.* This proposition may seem to be self-evident, but it is not, because it is meaningless until we connect it definitely with something physical. Let us consider, therefore, a

* This matter requires further explanation. Consider, for example, a rod which conducts heat steadily from a hot region to a cool region; to eliminate all changes of state outside of the rod we must imagine the hot region and the cool region each to consist of an infinite amount of substance. As another example consider the steady generation of heat in a wire by an electric current; in this case we may imagine an ideal, one-hundred-per-cent-efficiency dynamo driven by a very heavy fly wheel or by a heavy weight and cord so that purely mechanical changes, only, take place outside of the wire.

† By a sweeping process.

steady flow of electric current through a wire from which the heat is carried away by a stream of water so that everything remains unchanged as time elapses. Such a process is steady, that is, it remains exactly the same during successive intervals of time, and therefore any result of the process must be proportional to the elapsed time. Thus the amount of thermodynamic degeneration is proportional to the elapsed time and the amount of mechanical energy converted into heat is proportional to elapsed time. Therefore the amount of thermodynamic degeneration, ϕ, is proportional to the amount of work, W, degenerated. That is, we may write:

$$\phi = mW \qquad (1)$$

where m is a constant whose value depends only on the temperature of the body in which the degenerated energy appears as heat.

The higher* the temperature the smaller the value of m. This is evident from the following considerations: Let a quantity of work be degenerated into heat at a certain temperature, and let the heat so produced flow to a region of lower temperature. This flow is a sweeping process and it must, according to our assumption, involve *an additional amount of thermodynamic degeneration.* But the final result could be reached by the degeneration of the original amount of work into heat at the lower temperature, and if our assumption as to the existence of a quantity called thermodynamic degeneration is to be of value, we must assume that the amount of thermodynamic degeneration is the same for any two ways in which the same final result is reached from the same initial conditions. Therefore the lower the temperature the greater the value of ϕ in equation (1) and the smaller the value of m, the amount of work degenerated into heat being given.

As yet we have not agreed upon any measure of temperature. Therefore we are at liberty to adopt the quantity $1/m$

* The recognition of what we speak of as higher and lower temperatures does not depend upon any method for measuring temperature.

as our measure of temperature inasmuch as this quantity always has a definite value for any given temperature and inasmuch as its value is larger and larger the higher the temperature.* Consequently we may write $1/T$ for m in equation (1), and we have:

$$\phi = \frac{W}{T} \tag{2}$$

or, since W is equal to the heat H which has been produced, we may write:

$$\phi = \frac{H}{T} \tag{3}$$

It must be understood that this equation does not by any means define both ϕ and T, but when a definite and practicable means is established for measuring T, then ϕ is completely defined by this equation.

Note. It is a remarkable and significant fact that the simplest line of argument concerning thermodynamic degeneration should make it proportional to elapsed time. Indeed the two quantities, time and thermodynamic degeneration, do refer to the same condition in nature, to the universal forward movement of things which we all have come to think of as inevitable, and never to be reversed.†

Thermodynamic Degeneration and Entropy.

From the above expression for thermodynamic degeneration in terms of the dissipation of mechanical energy [see equation (2)] it is possible to determine the amount of thermodynamic degeneration involved in a simple sweep where the degeneration lies wholly in the relation between the initial and final states of the substance which undergoes the sweep. To make this determination theoretically, however, the equation of state of the substance must be known. Therefore let us

* This latter condition is by no means necessary.

† See a paper on "Entropy," by W. S. Franklin, *Physical Review*, Vol. XXX, pages 766–775.

consider an ideal gas (one that conforms to Boyle's law and one that does not change its temperature during free expansion, that is, when it expands without doing work). Initially let us have volume v of the gas at pressure p and at a given temperature T, and let this gas be carried through a two-stage cycle as follows:

(a) Let the gas be compressed at constant temperature, its volume being reduced by the amount Δv, the amount of work done on the gas being $p \cdot \Delta v$, and the amount of heat abstracted from the gas to keep its temperature constant being equal to the work done, namely $p \cdot \Delta v$. That we may keep clearly in mind the amount of work done on the gas and the amount of heat taken from the gas let us write:

$$\Delta W = p \cdot \Delta v = \Delta H, \tag{4}$$

where ΔW is the amount of work done and ΔH is the heat produced; this heat being abstracted from the gas as stated.

(b) Let the gas expand freely by suddenly increasing its volume to the initial value. Then the gas will settle to its initial condition (since temperature is not changed by free expansion).

Now process a is reversible and it involves no thermodynamic degeneration, whereas process b is a sweep. Therefore the thermodynamic degeneration resulting from the two processes a and b together must be due to process b alone. But the net result of both processes together is the conversion of the mechanical work $\Delta W = p \cdot \Delta v$ into an equal amount of heat ΔH at temperature T, and therefore the amount of thermodynamic degeneration involved is

$$\frac{\Delta W}{T} = \frac{p \cdot \Delta v}{T} = \frac{\Delta H}{T} \tag{5}$$

according to equations (2) and (3). Process b alone represents this amount of degeneration, and inasmuch as process b is a simple sweep, this degeneration lies wholly in the relation between the states of the gas before and after the change b

takes place. *Therefore there must be** *a quantity* ϕ ASSOCIATED WITH THE GAS *whose value depends on the state of the gas, and the process b must produce a definite increase of this quantity* $\Delta\phi$ *such that:*

$$\Delta\phi = \frac{\Delta W}{T} = \frac{p \cdot \Delta v}{T} = \frac{\Delta H}{T} \tag{6}$$

Substitute the value of p from the equation expressing Boyle's law, namely, $pv = C$, and we get:

$$\Delta\phi = \frac{C}{T} \cdot \frac{\Delta v}{v} \tag{7}$$

But throughout this discussion the temperature is assumed to be constant. Therefore by integrating (7) we get:

$$\phi = \frac{C}{T} \log v + \text{a function of } T \tag{8}$$

The complete determination of ϕ as a known function of volume and temperature involves the actual measurement of temperature, and it is best to leave this matter for the present. The quantity ϕ is called the *entropy* of the gas.

It is important to distinguish clearly between thermodynamic degeneration and entropy. The first is always associated with a sweeping process and it is a measure of the havoc wrought thereby, whereas entropy is a quantity which has a definite† value for a given substance in a given state. During a reversible process the total change of entropy of all the substances involved is zero. During a sweeping process there is, on the whole, an increase of entropy.

It is important to consider the equal and opposite changes of entropy of the gas and of its envelope during the reversible

* Must be, that is, if our original assumption as to the existence of thermodynamic degeneration is valid.

† A standard zero state of the substance must be chosen and for this state the entropy of the substance is taken as zero. Entropy is defined by a differential equation and it contains an indeterminate and essentially meaningless additive constant.

process a as above described. These changes must be equal and opposite because a is a reversible process. The entropy of the gas decreases during process a; this is evident when we consider that in being brought back to its initial state by process b its entropy increases, and the decrease of entropy of the gas during process a is equal to $\frac{\Delta H}{T}$ where ΔH is the heat taken from the gas during the process a. Therefore the increase of entropy of the envelope during process a is equal to $\frac{\Delta H}{T}$ where ΔH is the heat received by the envelope.

The envelope may be any substance whatever in thermal equilibrium, and therefore the entropy of any substance whatever (in thermal equilibrium) increases when heat is slowly imparted to it, and decreases when heat is slowly taken from it; and the very slow transfer of heat from one body to another at the same temperature (that is, when the temperature difference is infinitesimal) causes an increase of entropy of the body which receives the heat and an equal decrease of entropy of the other body.*

Proposition 1. Consider a substance which is slowly carried through a series of states of thermal equilibrium and brought back to its initial state, a reversible cycle, as it is called. The total change of entropy of the substance is zero because the final state of the substance is identical with its initial state. Therefore we must have:

$$\Sigma \frac{\Delta H}{T} = 0 \qquad (9)$$

where Σ indicates the summation of the values of $\frac{\Delta H}{T}$ for all the stages of the cyclic process, ΔH being considered positive

* When an amount of heat is taken from a body at high temperature T_1 and delivered to a body at low temperature T_2 the total change of entropy involved is $\frac{\Delta H}{T_2} - \frac{\Delta H}{T_1}$ and this total change of entropy is a measure of the thermodynamic degeneration involved.

or negative according as it represents heat given to or taken away from the substance.

Equation (9) is evidently true when we consider that the value of the quotient $\frac{\Delta H}{T}$ for any stage or step is the increase of entropy of the substance for that stage or step; the total change of entropy being obtained by adding all these increases together (some of which are positive and some negative).

Proposition 2. Consider a series of states of thermal equilibrium through which a substance may pass in going from an initial state A to a final state B. This series of states constitutes a *path* from A to B. Consider two such paths from A to B. Then $\frac{\Delta H}{T}$ is the same for both paths, and therefore $\Sigma \frac{\Delta H}{T}$ is the same for all such paths from A to B.

This is evident from the following considerations. Let C and D be two such paths from A to B. Let C be the value of $\Sigma \frac{\Delta H}{T}$ for path C, and let D be the value of this sum for path D. Then $-D$ is the value of the sum for path D *reversed*, because to carry the substance over path D in a reverse direction reverses the algebraic sign of ΔH at each stage or step. Therefore $C-D$ is the value of $\Sigma \frac{\Delta H}{T}$ for path C and for the reverse of path D taken together. But path C and the reverse of path D taken together constitute a closed path or cycle for which $\Sigma \frac{\Delta H}{T}$ is zero. *Therefore* $C-D=0$ or $C=D$.

Proposition 3. Any state A of a substance may be chosen arbitrarily as a zero or reference state and the entropy of the substance in this state may be taken as zero. Then the entropy of the substance in any other state B is equal to $\Sigma \frac{\Delta H}{T}$ for any reversible path leading from A to B.

For example, let us choose the zero state for water as ice at 0° C. Then to melt 100 grams of ice to form water at the same temperature would require 8000 calories or 33,600 joules and if we divide this by the absolute temperature corresponding to 0° C. we will get the value of $\Sigma\frac{\Delta H}{T}$ for the melting of the 100 grams of ice. Therefore, having chosen the zero state as specified, and taking 273° as the value of T* we get 123 joules per degree as the entropy of 100 grams of ice water, or 1.23 joules per degree as the entropy of one gram of ice water.

The Measurement of Temperature.

Consider an ideal gas of which the pressure is p and the volume is v. Then we have:

$$pv = Rt \tag{10}$$

where t represents temperature as measured by a gas thermometer.

Let this gas be carried slowly through a four-stage reversible cycle *abcd* as shown in Fig. 1.

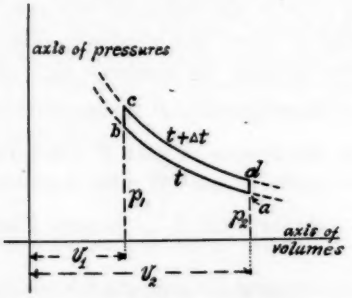

Fig. 1.

Stage 1. Beginning at state *a* let the gas be compressed to state *b* at constant temperature t. Then the amount of work,

* The measurement of T is discussed in the next paragraph.

W, done on the gas and the amount of heat, H, taken from the gas are both given by the equation:

$$W = Rt \cdot \log \frac{v_2}{v_1} = H \tag{10}$$

Stage 2. The gas is then heated at constant volume from temperature t to temperature $t + \Delta t$, that is from state b to state c, and an amount of heat Δh is given to the gas.

Stage 3. The gas is then expanded from state c to state d at constant temperature $t + \Delta t$; and the amount of work, $W + \Delta W$, done by the gas and the amount of heat, $H + \Delta H$, given to the gas are both given by the equation:

$$W + \Delta W = R(t + \Delta t) \cdot \log \frac{v_2}{v_1} = H + \Delta H \tag{11}$$

Stage 4. The gas is then cooled at constant volume from temperature $t + \Delta t$ to temperature t, that is from state d to the initial state a, and an amount of heat $\Delta h'$ is taken from the gas.

The quantities of heat Δh and $\Delta h'$ are equal because by free expansion the gas might be changed from state c to state d, and by free expansion the gas might be changed from state b to state a, so that the same amount of heat must be required to heat the gas from b to c as to heat the gas from a to d. Therefore let the common value of Δh and $\Delta h'$ be represented by Δh.

The increments of the entropy of the gas for each of the four stages are as follows:

Stage 1. $\dfrac{Rt \cdot \log \frac{v_2}{v_1}}{T}$.

Stage 2. $\dfrac{\Delta h}{T}$, infinitesimals of second order being dropped.

Stage 3. $\dfrac{R(t + \Delta t) \cdot \log \frac{v_2}{v_1}}{T + \Delta T}$.

Stage 4. $-\dfrac{\Delta h}{T}$, infinitesimals of second order being dropped,

where T and $T+\Delta T$ are the thermodynamic temperature values corresponding to t and $t+\Delta t$ respectively.

But the total change of entropy due to the entire cycle is zero. Therefore we have:

$$\frac{Rt\cdot\log\frac{v_2}{v_1}}{T}-\frac{R(t+\Delta t)\cdot\log\frac{v_2}{v_1}}{T+\Delta T}=0 \qquad (12)$$

which is easily reduced to the differential equation:

$$\frac{\Delta T}{T}=\frac{\Delta t}{t} \qquad (13)$$

which, by integration, gives:

$$T=kt \qquad (14)$$

where k is any constant. Let the value unity be chosen for k, then we have:

$$T=t. \qquad (15)$$

That is, the ideal gas thermometer measures thermodynamic temperature values.

Note. It is now possible to determine the unknown function of T in equation (8) on the assumption that the specific heat of our ideal gas at constant volume is constant.

The Efficiency of a Perfect Engine.

A perfect engine is one in which no sweeping processes occur, so that no thermodynamic degeneration takes place during the operation of the engine. Let H_1 be the heat supplied from the boiler at temperature T_1 and H_2 the heat given to the condenser at temperature T_2.* Then $\frac{H_1}{T}$ is the decrease of entropy of the boiler, and $\frac{H_2}{T_2}$ is the increase of entropy of the

* We cannot explain here exactly what must be done to reduce the action of a steam engine to a closed reversible cycle on a given portion of the working fluid. See Franklin and MacNutt's "Mechanics and Heat," page 367.

condenser; and if no sweeping processes occur the net change of entropy must be zero, so that:

$$\frac{H_2}{T_2} = \frac{H_1}{T_1} \tag{10}$$

According to the first law of thermodynamics we must also have:

$$W = H_1 - H_2 \tag{11}$$

where W is the work developed by the engine.

Now the fraction of H_1 which is converted into work is $\frac{W}{H_1}$ and this fraction is called the efficiency of the engine. Therefore, using equations (10) and (11) we may find:

$$\text{efficiency} = \frac{T_1 - T_2}{T_1} \tag{12}$$

For example let T_1 be 400° absolute, and let T_2 be 350° absolute. Then the efficiency, according to equation (12), would be $\frac{50}{400}$ or $\frac{1}{8}$. This result applies only to a perfect engine, and an actual engine working between the same temperatures must be less efficient, because in this case the increase of entropy of the condenser $\frac{H_2}{T_2}$ must be greater than the decrease of entropy $\frac{H_1}{T_1}$ of the boiler, because the sweeping processes which take place in the actual engine involve a certain amount of thermodynamic degeneration.

STATEMENTS OF THE SECOND LAW OF THERMODYNAMICS.

(*a*) The thermodynamic degeneration which accompanies a sweeping process cannot be directly repaired, nor can it be repaired by any means without compensation.

This is an entirely general statement of the second law and the two terms *direct repair* and *compensation* must be explained.

The direct repair of the havoc wrought by a sweeping process means the undoing of the havoc by allowing the sweep to perform itself backwards, an idea as absurd as the idea of allowing a burned house to unburn itself!

One can, of course, rebuild a burned house, but a certain amount of expense is involved. Also the havoc wrought by a sweeping process can be repaired, but when such repair is finished some other substance is always left in what may be called a degenerated state. The original sweep represents a certain increase of entropy of the substance involved, and when the effects of the sweep are repaired, even by ideal reversible processes, this increase of entropy (thermodynamic degeneration) is handed along to some other substance. This equivalent degeneration of the other substance is what is referred to by the use of the word compensation.

(*b*) Heat cannot pass directly from a cold body to a hot body, nor can heat be transferred from a cold body to a hot body by any means without compensation.

This reference to the direct passage of heat from a cold body to a hot body should recall what has been said about a piece of iron lying quietly in a pail of water and becoming suddenly red hot and jumping out of the pail!

(*c*) Heat cannot be converted directly into work, nor can heat be converted into work by any means without compensation.

The direct conversion of heat into work means the simple reverse of any ordinary sweeping process which involves the degeneration of work into heat. For example work is degenerated into heat in the bearing of a rotating shaft, and every one knows that to reverse the motion of the shaft does not cause the bearing to grow cold and the heat so lost to appear as work helping to drive the shaft! That would be a rotary engine indeed!

(*d*) A gas cannot pass directly from a region of low pressure to a region of high pressure, nor can a gas be transferred

from a low pressure region to a high pressure region by any means without compensation.

Imagine a gas squirting itself backwards through a nozzle into a high pressure reservoir! But the second law of thermodynamics is the statement of a fact which everyone knows coupled with a generalizing clause or postulate which no one can understand until some of its consequences are derived and tested by experiment.

Here is one more statement of the second law of thermodynamics, the oldest English version of it:

> Humpty Dumpty sat on a wall.
> Humpty Dumpty had a great fall.
> All the King's Horses and all the King's men
> Cannot put Humpty Dumpty together again!

This is perhaps the most sensible of all the statements of the second law, for which we will allow it to pass for the moment, because it ignores direct repair and refers at once to the most powerful of external means. It is important to understand, however, that in Humpty Dumpty's case we are concerned with structural degeneration, not with the vastly simpler kind of degeneration which, for example, takes place when you produce turbulence in a pail of water by stirring. Of course the water can be easily brought back to its initial condition, but a certain compensation is always involved.

Of all the generalizations of physics the second law of thermodynamics is the most deeply seated in human experience and intuition, and one of the most humorous of childrens' verses refers to the man whose wondrous wisdom enabled him to circumvent it by direct repair!

> There was a man in our town,
> And he was wondrous wise;
> He jumped into a bramble bush
> And scratched out both his eyes.
> And when he found his eyes were out,
> With all his might and main,
> He jumped into another bush
> And scratched them in again.

But let us return to the fourth statement (*d*). A gas can be transferred from a low pressure region to a high pressure region by means of a pump, and the work that is used to drive the pump, even supposing the pump to be frictionless, is all converted into heat. This conversion of work into heat is the compensation for the transfer of the gas as specified.

Or consider the second statement (*b*). In an artificial ice factory heat is transferred from the freezing room to the warm outside air, but the work required to drive the ammonia pump, even supposing it to be frictionless, is converted into heat.

Or consider the third statement (*c*). An ordinary steam engine converts heat into work, but even with an ideal or perfect engine a large amount of heat must be supplied to the engine at boiler temperature and a large portion of this heat must be let down to the temperature of the exhaust and pass out with the exhaust to compensate for the conversion of the remainder into work.

Let the reader understand that everything up to this point is purely hypothetical inasmuch as everything depends upon the assumption that there is such a quantity as thermodynamic degeneration. To establish this hypothesis as a principle it is of course necessary to follow its logical consequences and submit them to the test of experiment.

The Use of Thermodynamics in Engineering.

Thermodynamics includes the whole of the subject of heat and the whole of the subject of chemistry.* This apparently is not the point of view of those who teach thermodynamics to engineering students, and it certainly is not the point of view of engineering students who study thermodynamics; indeed, as it seems to us, very few of the latter ever reach any intelligent point of view regarding the subject.

The general subject of heat is, of course, very important to

* The atomic theory is not a branch of thermodynamics, it is an independent method. This matter is discussed in a very simple way on pages 273–278, and 343–349 of Franklin and MacNutt's "Mechanics and Heat."

the engineer, but the discussion of the second law of thermodynamics in its application to steam and gas engines is not by any means as important as many of our teachers of mechanical engineering seem to think.

1. The second law of thermodynamics leads to a general idea as to what determines the efficiency of an engine, namely, (*a*) a large value of the ratio T_1/T_2 [see equation (12)], and (*b*) the elimination of sweeping processes to the greatest possible extent. But concerning this second matter, (*b*), which involves most of the problems of engine design, the second law gives no further information whatever.*

2. The second law of thermodynamics is indirectly useful to the steam engineer because by means of it certain relations between latent heats and freezing and boiling temperatures are established, so that such things as steam tables can be calculated from indirect data to a certain extent.

3. Another, and by far the most important, use of the second law of thermodynamics to the engineer might be realized if he could be given a clear and adequate understanding of its meaning in connection with physics and chemistry.

Beyond these three things the study of "thermodynamics" by the engineering student is of no value. Indeed there are many respects in which this study has less than no value. In illustration let us consider a matter which is a hobby with many steam-engineering thermodynamists, namely, the beautiful temperature-entropy diagram of the steam engine. This diagram is simple because all of the calculations which have to be made to interpret actual pressure, volume and temperature measurements must be made before the temperature-entropy diagram can be drawn, and to enthuse over the simplicity of this diagram is on a par with the following: Suppose one has derived a numerical result of 265 inches from painstaking measurements and calculations, and imagine one foolish enough to believe that instead of puzzling over the difficulties involved

* A very concise statement of this matter is given on pages 371–373 of Franklin and MacNutt's "Mechanics and Heat."

in these measurements and calculations one could substitute as an equivalent therefor the easy task of saying to one's self 2 is two and 6 is six and 5 is five! To use the temperature-entropy diagram is to contemplate a result in this meaningless way with a false sense of one's superior wisdom, forgetting everything else.

Another hurtful influence of the study of "thermodynamics" by the engineering student is illustrated by the following incident. One of the very best students in a recent senior class was carrying a new book on gas engines (and a good book it was, by the way) when he was asked if the book contained any information concerning ignition temperatures of various gas and air mixtures, whereupon he beat around the bush and with a show of wisdom explained how such data could be calculated! The poor fellow could not be seriously blamed for his stupidity, however, for meaningless and fudged calculations have been made to take the place of clear practical thinking in many of our specialized studies for engineering students. There is no conceivable result which some teacher-men do not pretend to calculate! from guessed data! And this is called Technical Education!

Theoretical Physics and Graduate Study.

Every advanced student of the physical sciences should have some understanding of at least one highly elaborated branch of mathematical physics, such as Advanced Rigid Dynamics, Hydrodynamics, Electro-magnetism, Statistical Mechanics, or Thermodynamics; but we believe, with Steinmetz, that nothing is so bad in the training of a scientific worker as too much of these good things. Next to actual experimental research and the reading of original memoirs, the greatest need in our graduate schools of science and technology is an increased emphasis on the fundamentals of physical theory in courses which are dominated by ideals of simplicity and directness. This paper on the second law of thermodynamics is therefore sent out as a message to the teacher of pure science as well as to the teacher of applied science.

HIGHWAY ENGINEERING AT THE AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS.

BY R. L. MORRISON,

Professor of Highway Engineering, Agricultural and Mechanical College of Texas.

The chair of highway engineering at the Agricultural and Mechanical College of Texas was established in April, 1910, as a division of the department of civil engineering. The instruction in this subject consisted of a three-hour course in the sophomore year, and the professor of highway engineering devoted a large part of his time to promoting highway improvement in all parts of the state by means of lectures, exhibits of road models, and general advice to local road officials.

In the summer of 1914, an associate professor was added to the highway engineering staff, a well-equipped road materials testing laboratory was installed, and the United States Office of Public Roads detailed a highway engineer to the college to assist in the extension work. This extension work occupied most of the time of the entire staff, as the instruction in highway engineering consisted of only two hours in the junior year and three hours in the senior year of the regular civil engineering course, with a short course for road supervisors given for four weeks in the winter.

Beginning with the present academic year the college will offer a four-year undergraduate course in highway engineering as an option in civil engineering. This course is the same as the course in general civil engineering until the second term of the junior year, when a course in rural highways is given instead of the condensed general course in highway engineering which is given to the regular civil engineering students.

Beginning with the ordinary earth road, the various types of surfaces, such as sand-clay, gravel, shell and water-bound

macadam, which are most commonly used for country roads, are studied. In the senior year bituminous materials and their application to highway work are taken up in a five-hour course in the first term, and the study of the different types of surfaces is completed in the second term of the senior year by a course in non-bituminous pavements. Sidewalks, curbs and gutters, and street cleaning are also studied in this course. The three courses outlined above really form one continuous course in the construction and maintenance of all types of road surfaces.

The usual laboratory course in testing road materials, and a course in highway bridges and culverts are given in the senior year, also a course which covers preliminary investigations, selection of proper types of surface, road and street design, the design of road and street systems, and the elements of city planning.

Highway engineers are often confronted by the business phases of their undertakings earlier in their careers than engineers in other lines, and the men from whom they receive instructions are often politicians who know little about proper and efficient business methods, so that they must depend largely upon the engineer for advice in such matters. To meet this condition a two-hour course is given covering highway laws, highway economics, and the organization and administration of state, county, and municipal highway departments. This is in addition to the usual courses in contracts and specifications and economics.

The subjects omitted from the course in general civil engineering in order to make room for the highway engineering subjects are railroad drafting, irrigation, sewerage, and higher structures.

The short course, given during two weeks in January, is not rigidly prearranged, but is left sufficiently elastic so that it can be adapted to the needs of the majority of the men who come to take it.

An unusual feature in connection with the highway work at this college is the offering of what are called reading courses.

There are doubtless many men, including engineers, who may not find it convenient to attend the regular courses in highway engineering, but who would like to take advantage of the college facilities to do studying along special lines adapted to their particular needs. To such men the college offers the use of its libraries, laboratories, and other facilities. The members of the highway engineering staff can be consulted at any time and will outline courses and put the student in touch with the best sources of information on any subject. These courses will be available only to men over twenty-one years of age.

It is believed that by means of the regular course, short courses, and reading courses provision has been made for offering just what is desired to every one seeking instruction in highway engineering. No certificates of any kind are issued to students in the short course, or reading courses, so that the college standards are in no way lowered by giving instruction to those who can not enter as regular students.

The extension work of the division of highway engineering is being carried on along the following lines:

Collection and distribution of data regarding highways in Texas and other states and foreign countries.

Public lectures on the benefits of good roads, methods of financing road improvements, and proper methods of construction and maintenance.

Bulletins and press articles on similar subjects.

Good roads exhibits at fairs and on good roads trains.

Inspection of county road systems and advice to local officials regarding organizations of county highway departments, highway accounting systems, mechanical equipment, maintenance of earth roads, and any other local road problems.

Assistance in local campaigns for construction of improved roads, including inspection of existing roads, general advice regarding best methods of improvement, and rough estimates of cost on which amount of bond issue may be based.

Laboratory tests on brick, stone, gravel, shell, sand, clay and other road materials.

Advice on road problems is also given by correspondence.

The college does not undertake to make surveys, plans, or detailed estimates of cost or supervise construction. In other words, it does not do the work which would be expected of an engineer in charge of location and construction. The advice of the college engineers is preliminary to, but not a substitute for, such regular engineering service.

The following bulletins have been published by the division of highway engineering: Texas Road Laws, Benefits of Good Roads, Earth Roads, Highway Bridges and Culverts, Gravel Roads.

The services of the division of highway engineering are offered to all organizations and individuals in Texas who are interested in highway improvement, and no charge is made for advice, bulletins, laboratory tests or other assistance.

SOME NOTES ON THE WRITING OF COMPOUND TECHNICAL TERMS.

BY C. W. PARK,

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At the recent annual convention of the Society for the Promotion of Engineering Education, the Committee on Technical Nomenclature submitted a preliminary report, in which attention was called to a number of glaring inconsistencies in the writing and use of technical terms. The purpose of this committee, as explained by the chairman, Professor John T. Faig, is not to impose arbitrary standards upon others, but to secure agreement throughout as wide a circle of technical men as possible, regarding the way in which disputed terms shall be written and understood. To this end, the committee has asked for criticisms and suggestions which may result in a better understanding, and perhaps a partial solution, of the problem.

On most questions of interpretation—for example, the distinction between "drill press" and "drilling machine," teachers of English will hardly be expected to venture an opinion. Such controversies may safely be entrusted to persons having expert knowledge of the technical subject involved. Where the issue is primarily one of correctness or consistency of usage, however, some assistance may properly come from those who are interested in expression rather than subject matter. This is particularly true, if as in the present instance, the chief object in studying usage is to deduce from it some practical generalizations as a basis of agreement among writers. It is with the desire to learn the conclusions of others, and perhaps in a small way to aid the committee in their efforts toward the standardization of existing practice, that I offer the following observations on the writing of compound technical terms.

THE WRITING OF COMPOUND TECHNICAL TERMS.

Perhaps the most distinctive feature of the technical vocabulary is its large proportion of compound words. To be sure, one does not encounter in every line such striking examples of compounding as, *"a three-step-cone, double-back-gear, two-countershaft-speed, screw-cutting lathe,"* but similar agglomerations are by no means rare, and with the growing complexity of machines and processes, their number is rapidly increasing. Shorter compounds are so common in technical writing that they might pass unnoticed, were it not for one thing: the perpetual uncertainty as to how they shall be written.

One's first impression, on reading a page of engineering discussion, is that there is no law or custom governing the writing of compound technical words. Even one of the most familar compounds is written in three ways, "horsepower," "horse-power," and "horse power." Other words in every-day use, such as "switchboard," "waterproof," "blueprint," "crankshaft," are written in two or three ways. Moreover, instances are not wanting in which two or three forms of the same compound are used in the same issue of a given magazine, and even in different parts of a single article. For those who prefer to write consistently, and at the same time with the sanction of usage, this disparity of precedents is hopelessly bewildering. Some comfort, of course, is to be derived from the lists of words which various persons interested have compiled from time to time; but since these lists cannot be exhaustive, and are not always accessible, it would seem desirable to supplement them with a statement of principles which could be more readily and more generally applied.

Some time ago, with the assistance of a class in technical English, I undertook an investigation of the vexing question of writing compounds. We began with lists of words, of the kind already mentioned, and added a number of rules from text-books, some general discussions of the subject of compound words—for example, in the Standard Dictionary, and a few hair-splitting distinctions between special cases, from the *Inland Printer* and other sources. The lists were con-

veniently specific, but certain inconsistencies in many of them suggested that they had been chosen arbitrarily, rather than by well-defined principles of selection. Many of the rules were helpful, but some of them were too uncertain of application to be useful.* The discussions were interesting, and in many respects valuable, but scarcely practical as a guide to writers. The students showed a remarkable aptitude for finding exceptions to both lists and rules; and so potent a superstition is the sanctity of the printed page, that once having seen a certain form of a word in type, they felt forever free to use that form. In fact, the more we studied the question of compound words in general, the more conflicting the evidence became. The next plan adopted was to lay aside rules and precedents, and to undertake an investigation of the technical journals themselves, in order to see whether in the apparent confusion there existed any discernible basis of agreement in the writing of compound words. That there would be some "lawless exceptions" was confidently expected; but it was felt that if a general tendency could be discovered, or if some working rules or principles could be formulated, a comparison of practice would be worth while. Twenty representative technical journals were examined, and about two hundred compounds were tabulated—a sufficient range of material to warrant some fairly trustworthy inferences, if not positive assertions. Too specific mention of the journals is perhaps undesirable, and the details of the investigation would be tedious to include; but some of the facts observed may be of interest.

In the first place, it was noted that in a fairly large proportion of individual journals there was sufficient uniformity in the writing of compounds to indicate an effort at standardization, perhaps through a carefully prepared style sheet, or a

* In one excellent text-book on engineering English, for example, the rule for adjective compounds was short, easy of application, and in accordance with what was found to be the practice of writers. The same book contained a rule for compound nouns which proved confusing, rather than helpful to any one in quest of a working principle.

competent "style man." Second, a comparison of the various journals showed a tendency toward uniformity throughout the group. Consciously or unconsciously, it seemed, certain principles were being followed, which might be made more useful by being formulated. Incidentally, it may be remarked that these rather surprising facts were only a part of the evidence which showed that engineering journals are rapidly developing a technique of their own.

The practice of American technical journals with reference to the writing of compound words may be briefly stated as follows:

1. *Write compound nouns without the hyphen;** that is, either as two words in the case of separable, or loose, compounds ("cast iron," "friction clutch," etc.), or as one word in the case of inseparable, or close, compounds ("roadway," "falsework," etc.).

2. *Write adjective compounds with the hyphen; e. g.,* "four-cylinder automobile," "cast-iron frame," "low-pressure system," etc.

The second rule is subject to some exceptions, including a few close, or inseparable, compounds, *e. g.,* "overshot wheel," "waterproof lining," etc. More of the exceptions fall under a general rule, which may be stated as follows:

3. *Omit the hyphen wherever the meaning is clear without it; e. g.,* "power plant economy," "machine tool design," etc. This rule is made of course in the interest of further simplification. It includes rule no. 1, and is a corrective for rule no. 2. Obviously, the easier plan would be to follow the second rule consistently, regardless of the number of hyphens which clogged the text. The adoption of rule no. 3 results in a cleaner text, but it necessitates writing with greater discrimination, to decide where the hyphen is needed for clear-

* It may be interesting to contrast the tendency of certain English writers. Here are some compound nouns taken at random from *Engineering* (London), "air-pump," "motor-car," "pig-iron," "gas-main." One or two rather prominent American journals show a preference for the hyphen in all such cases.

ness and where it may safely be omitted. No difficulty is likely to be experienced in the case of such expressions as "machine shop methods," but an expression like "cold-rolled steel" should be written with the hyphen regardless of the context. Those who cannot easily distinguish the relative clearness of such compounds written with and without the hyphen, will do well to avoid attempting to use rule no. 3.

In the various magazines examined there were of course some exceptions to these rules, and there were also differences in the degree to which the rules were followed. Although some of the exceptions are not without apparent validity,* they are omitted, in order not to obscure the main issues. As we have noted, the rules represent rather the general tendency of usage than the deliberate and consistent practice of technical writers. This agreement in general tendency, however, is significant; for it indicates what will probably become the settled tradition in technical journals. If the practice is wrong, it is high time to set about correcting it. If it is right —that is, if besides being simple and convenient, it can be reconciled with any defensible theory of compounds,—then it should be encouraged, and its general adoption should be hastened. Although the rules embodying the practice are stated in terms of the hyphen, it is evident that the hyphen itself is purely secondary, and that the rules have weight only in so far as they rest upon a sound theoretical basis. Before passing judgment on the rules, therefore, it will be well to consider briefly the theory of compound words.

A compound word is formed by the union of two or more words in a special sense, other than that conveyed by simple grammatical relationship. As in mathematics a quantity enclosed in marks of parenthesis is regarded in its entirety, so a compound word is considered as a whole, rather than as a succession of separate parts. We may of course recognize the parts—as we do in the case of many derivative words,—but the test of a compound is whether the expression as a whole

* For example, the compound nouns, "foot-pound," "kilowatt-hour," and similar expressions.

constitutes a single word. Within the compound, the first part usually limits, or qualifies, the second part, and receives the stronger accent. Thus, in "gas producer" and "producer gas," the descriptive part of the compound word comes first and is accented in order to distinguish the kind of producer, or gas. The importance of accent in compound words, as will be more fully explained later, is twofold; in that it not only aids in identifying the expression as a compound, but also indicates the extent to which the parts are unified.

Loose, or Separable Compound Nouns.

Compound words vary widely in the closeness of the relationship between their parts. In the case of compound nouns, for example, we have at one extreme the loosely connected pair of words only one step removed from being a simple word and its modifier. Such words as "motor truck," "drill press," and "machine tool" clearly unite to express a single idea, but they are not felt to be inseparable. Each retains its identity and a certain degree of its original accent. In such cases, the preference of most technical writers is for the omission of the hyphen. (Rule No. 1.) Several reasons may be assigned for this preference. The comparative independence of the words is recognized, the meaning is made sufficiently clear by juxtaposition, the text is cleaner, and the problem of writing is simplified by putting the compound in the form of two words. Or perhaps we may say that the hyphen is taken for granted; an invisible hyphen, as it were, connects the parts of the compound. Some engineers with whom I have discussed this question insist that these compounds, being technical, and being written almost wholly for technical men, need not be labeled in order to be understood. One man gave this as his reason for wishing to abolish the hyphen altogether. Whether we are willing to go so far or not, we must admit the validity of the argument that technical men have a right to be consulted as to the form of their own vocabulary. At any rate, compound nouns are not likely to be misunderstood by the technical men who use them. The following list contains only

a few examples of the large class of compound nouns which in most technical journals are written as two words.

air chamber	end thrust	oil groove
air compressor	engine room	oil pan
air pump	escapement wheel	oil well
arc lamp	feed water	ore bed
balance wheel	freezing point	peak load
ball bearing	friction clutch	pig iron
blast furnace	gas engine	pipe tongs
boiler room	gas producer	pipe wrench
cast iron	gate valve	power plant
coal dust	generator room	pressure gage
coal tar	lamp cord	pump room
cost reduction	locomotive engineer	pump shaft
double track	machine shop	safety valve
drafting board	machine tool	sheet iron
drafting room	motor car	steam chest
drill press	mud drum	store room
dust guard	oil cup	surface elevation

It would be easy enough for the captious critic to place a strained interpretation on many of these pairs of words. Every one is familiar with the type of person who with an air of great subtlety would point out that "rolling mill" without the hyphen might mean a mill which is constantly describing a rotary motion. This kind of critic is only a harmless Dundreary, who lacking the restraining influence of a sense of proportion, delights in discovering all manner of absurd ambiguities. We know, for example, how Dundreary at his worst would soliloquize over an everyday expression such as "vacuum cleaner." "Why should anybody *want* to clean a *vacuum?*" And then, in a burst of triumphant reasoning, "What could he possibly *find* to clean, in a vacuum? What a perfectly superfluous invention!" It is perhaps not putting it too strongly to say that many objections to the separation of compound technical terms would belong in this class. They would be exceedingly far-fetched, and would differ in degree rather than in kind from the exaggerated perversions of a Dundreary.

Close, or Inseparable Compound Nouns.

At the opposite extreme from the separable compounds is a class of compound nouns which, because of close connection and long association, are written solid. In these words, the literal meaning of the separate parts has become obscured or forgotten, and the result is a single word that has become completely unified. "Foreman," for example, is felt to be as closely unified as the simple word "boss," or as the derivative, "superintendent." The tendency toward close unification is strong in compound words which are much used, particularly if they are spoken, rather than written. To the eye, a term like "forecastle," though closely unified, shows its original makeup, but the spoken word has become something like "focsl," showing the sailor's recognition of its unity and his disregard of its elements. Other examples of nautical terms which will readily suggest themselves are "bosn" for "boatswain," and the remarkable condensation "fotogansl," scarcely recognizable in its spoken form as "foretop-gallant-sail." What takes place in these oft-used compounds is true to a lesser degree in the familiar compound words of other associations. Usually, the strong accent given the first part of the word—an involuntary testimony to the extent of its unity—aids one in deciding whether a compound word has gained its right to be written solid. Though the practice varies somewhat, the following words are representative of a fairly large class of compound nouns which are preferably written solid.

airship	bulkhead	cutoff	horsepower
backfire	busbar	drawbar	hotwell
battleship	camshaft	engineman	input
bedplate	candlepower	falsework	intake
bedrock	capscrew	firebox	jackshaft
blowoff	countershaft	flashlight	keyseat
blueprint	crankpin	flywheel	lookout
brakeshoe	crankshaft	foreman	manhole
brasswork	cribwork	framework	network
breakdown	crosshead	gangway	offset
bucketful	crowbar	handbook	orebody

overflow	roundhouse	tailrace	watershed
output	runway	tailstock	waterwheel
passageway	sandpaper	tidewater	wattmeter
penstock	spillway	turntable	wheelbase
railroad	standpipe	underframe	woodwork
rainfall	stockholder	voltmeter	workmen
roadway	switchboard	washout	wristplate

In some discussions of compound words an effort is made to distinguish an intermediate degree of intimacy between the separable and the inseparable compounds, and the hyphen is used to mark the middle shade of relationship. This distinction offers many excellent opportunities for argument, but there is little evidence to show that technical writers in general pay any serious heed to it. On the whole, they are probably justified in disregarding a difference so difficult to determine and of so little practical value. By distinguishing broadly between only two classes, the separable and the inseparable compounds, they at least reduce the area of debatable ground.

Compound Adjectives.

The use of the hyphen in compound adjectives is more common than its omission in compound nouns. There is a grammatical principle, which, whether stated or not, doubtless accounts for the joining of adjective compounds. In expressions like "cast-iron frame," or "crude-oil engine," for example, if some arbitrary sign were not used to show that the two words as a unit modify the noun, the natural inference would be that they were separate adjective modifiers. Thus, "a cast iron frame" might indicate that the iron was cast in one piece, and "a crude oil engine" might mean an engine, crudely designed, using oil as fuel. These distinctions, it will be observed mean more than the Dundreary quibbles mentioned in the discussion of separable compound nouns. As a matter of fact, the compound adjective consists of a modified modifier. First, the base of the compound is limited by the descriptive part; then, in its modified form, it in turn describes a noun. In the expression, "low-water mark," for

example, "water" is modified within the compound, and the new word thus formed modifies "mark." Perhaps in the brief discussion of adjective compounds on page 5, too strong a case was made for rule no. 3. Although in many adjective compounds, such as those cited under rule no. 3, the meaning could hardly be mistaken if the expression were written as two words, nevertheless, there is much to be said for the practice of using the hyphen regularly between the parts of the compound adjective. (Rule No. 2.) The hyphen emphasizes the intended construction, and errs, if at all, on the side of clearness. In addition to this advantage, there is some satisfaction in being able to use the hyphen consistently.

The examples given below are chosen to illustrate the principal ways in which adjective compounds are formed.

Noun + Noun Compounds.

tool-room (practice)
machine-tool (operation)
motor-generator (set)
railway-accident (problem)

Numeral + Noun Compounds.

two-cycle
four-inch (4-inch)
six-cylinder
40-horsepower
three-ply
2200-volt
16-candlepower
third-class

Descriptive Adjective + Noun.

high-speed (engine)
open-hearth (process)
heavy-duty (engine)
high-potential (insulator)
cast-iron (frame)
high-pressure (system)

Compound Participial Adjectives.

wedge-shaped
nickel-plated
motor-driven
shunt-wound
direct-connected
home-made
cold-rolled
water-jacketed
high-priced
wood-working (machinery)
wire-drawing (machine)
cost-keeping (methods)

Phrase Compounds.

drop-of-potential (method)
make-and-break (ignition)
two-by-six (rafters)

Expressions like the above, whether nouns or adjectives, are regularly written with the hyphen.

To revert to the three rules, I am not quite prepared to advocate their unqualified adoption, or to suggest definite limits within which they should be applied. They have been brought together primarily as a statement of what a more or less informal investigation shows to be the chief tendencies in this regard among technical writers. Personally, I confess to a rather deep-seated prejudice in favor of the hyphen in most compound words which cannot be written solid. I must admit, however, that there is much common sense in the practice of technical men, and that so far as I have observed, they have not seriously offended against the theory of compound words. Without doing violence to the meaning of compounds, they have been working toward a simpler and more uniform method of writing. It is hardly likely that such rules could ever be generally adopted ouside of technical contexts, but where there is much repetition of certain compounds, and a limited reading public, to whom the expressions are familiar as technical terms, the opportunity for agreement upon a conventional practice is excellent. Surely such a result would justify concessions by individuals in many matters of personal preference. If the Committee on Technical Nomenclature and others working with them can bring about the substitution of uniformity and greater simplicity for our rather complex and inconsistent ways of writing technical terms, they will have earned the gratitude of all who have to do with engineering English.

FIRST STUDY OF THE GENERAL ALTERNATING-CURRENT CIRCUIT.

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The difficulties encountered by beginners in the study of the elementary alternating-current circuit can be successfully removed by the use of an inexpensive set of resistance, inductance and capacity units given over to the student for his own investigation.

The resistance consists of 44 ohms of No. 22 IaIa wire wound non-inductively on two parallel plates of vulcanized fiber with the turns spaced far enough apart to allow very free ventilation.

The inductance coil is wound on an iron core made up of laminations from an old shell type transformer. A large enough air gap was introduced in each magnetic circuit to keep a fairly constant inductance of 0.117 henry.

The capacity consists of thirty Siemens & Halske condensers tested to 500 volts. Each is of 2 microfarads capacity. For convenience they are arranged in three cases with the terminals of the ten condensers in each case so brought out that, with plug contacts on the hard rubber top, any series or parallel combinations can be effected.

To aid in making any combination of the resistance, inductance and capacity units as well as for facilitating the shifting of ammeter and wattmeter to various parts of the circuit, the switchboard indicated in the figure is provided. The large brass blocks have ½-inch tapered holes for the regular laboratory jumpers or connectors which have tapered plug terminals. Similar blocks form the terminals on the three units.

The smaller holes indicated in the switchboard blocks are also tapered to take the special tapered plug connectors for ammeter and wattmeter.

The connections indicated in the figure are for all three units in parallel with the ammeter and wattmeter in the condenser branch. The plug connectors for these instruments can be transferred to another branch in an instant and, upon the opening of the switch between them, the instruments will indicate for that branch. The units are connected in series by putting one between points *A* and *B*, a second one between *C* and *D* and the third between *E* and *F*. In this case the brass plug at *G* is removed.

Each unit will take approximately 2.5 amperes from a 110-volt 60-cycle circuit and a 5-ampere ammeter, a 125-volt voltmeter and a 2-ampere, 150-volt wattmeter are well suited for the test. A frequency meter is desirable.

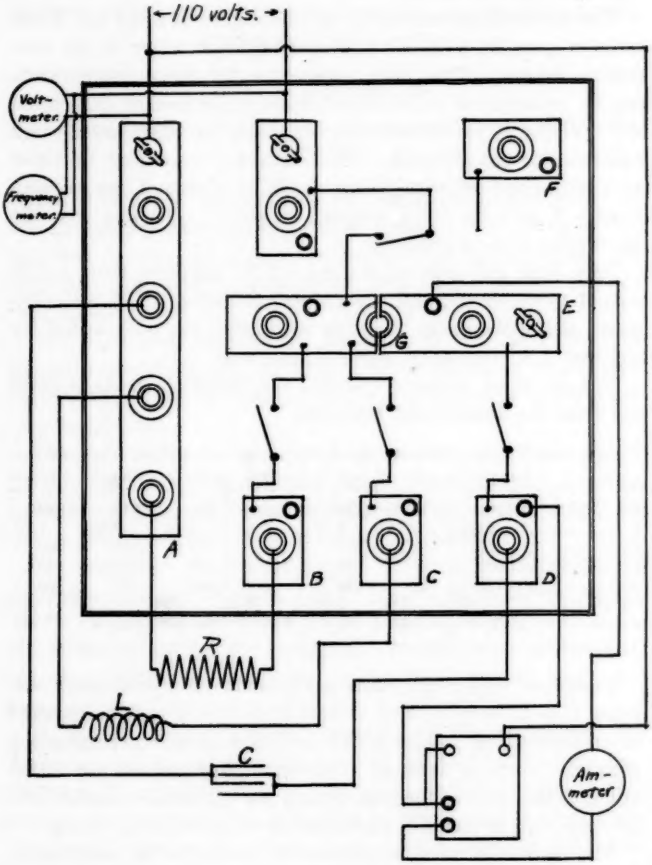
For all three units in parallel the following table is filled out from the instrument readings.

	C	*L*	*R*	*C*+*L*	*L*+*R*	*R*+*C*	*C*+*L*+*R*
E	110	110	110	110	110	110	110
I	2.52	2.74	2.58	0.4	3.85	3.62	2.76
P	2.5	14.5	286	16	296	285	300
f	60	60	60	60	60	60.5	60
*E*x*I*	277	301	284	44	424	398	304
Cos φ	.009	.048	1.00	.364	.698	.717	.986
φ	89° 29′	87° 15′	0° 0′	68° 40′	45° 45′	44° 11′	9° 30′

Complete vector diagrams are drawn. The combined currents C + L, L + R, R + C and C + L + R will be checked in an interesting fashion by the addition of the corresponding separate current vectors. Corresponding tables are filled out and the vector diagram drawn for all units in series and for, say, two in parallel connected in series with the third.

The approach to a condition of resonance is most easily studied by taking the current from a synchronous converter operating as a direct current shunt motor. Thus, through its field rheostat, its speed and therefore the frequency of the

alternating current can be changed at will without changing the alternating voltage. With all units in series and a fre-



quency below the critical or resonant value the voltage across the inductance will be less than, at the critical frequency

equal to and above the critical frequency greater than that across the capacity.

The degree of error of the wattmeter at the low power factors may be ascertained by readings with potential coil of the wattmeter connected across the other phases of the converter or generator.

REPORT OF AN INSTITUTIONAL DELEGATE.

BY C. L. CORY,

Dean School of Engineering, University of California.

TO THE PRESIDENT OF THE UNIVERSITY AND COUNCIL OF ENGINEERING AND APPLIED CHEMISTRY, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA.

Gentlemen: As the delegate from this University to the Twenty-third Annual Meeting of the Society for the Promotion of Engineering Education, of which the University of California is an institutional member, held at Ames, Iowa, June 22–26, 1915, I beg to present the following

REPORT.

The general meetings were held in the auditorium of the main engineering building of the Iowa State College. The President of the Society and presiding officer was Mr. Anson Marston, Dean of the Division of Engineering, Director of the Engineering Experiment Stations, and Professor of Civil Engineering in the above institution.

One hundred and seventy-seven members and guests registered at the Convention. The attendance at all of the sessions was most satisfactory.

The forty-nine institutional members of the Society at the date of the meeting, and the year during which each institution was elected to membership, are as follows:

Institution.	Year.
1. Municipal University of Akron, Akron, O.	1914
2. Alabama Polytechnic Institute, Auburn, Ala.	1914
3. University of Arizona, Tucson, Ariz.	1914
4. Brown University, Providence, R. I.	1914
5. University of California, Berkeley, Calif.	1913
6. *Carnegie Institute of Technology, Pittsburgh, Pa.	1915
7. Case School of Applied Science, Cleveland, O.	1913
8. The Citadel, The Military College of South Carolina, Charleston, S. C.	1914
9. Clemson A. & M. College, Clemson, S. C.	1913

10. Cornell University, Ithaca, N. Y. 1913
11. Drexel Institute, Philadelphia, Pa. 1914
12. The George Washington University, Washington, D. C. 1913
13. Georgia School of Technology, Atlanta, Ga. 1913
14. †Harvard University, Cambridge, Mass. 1913
15. Iowa State College, Ames, Ia. 1913
16. State University of Iowa, Iowa City, Ia. 1914
17. Kansas State Agricultural College, Manhattan, Kans. 1915
18. The University of Kansas, Lawrence, Kans. 1914
19. Lehigh University, South Bethlehem, Pa. 1914
20. Miami University, Oxford, O. 1913
21. Michigan College of Mines, Houghton, Mich. 1914
22. University of Michigan, Ann Arbor, Mich. 1913
23. University of Missouri, Columbia, Mo. 1914
24. University of Nebraska, Lincoln, Nebr. 1914
25. New York University, New York, N. Y. 1913
26. The University of North Dakota, Grand Forks, N. D. 1913
27. University of Notre Dame, Notre Dame, Ind. 1913
28. Ohio Wesleyan University, Delaware, O. 1914
29. State University of Oklahoma, Norman, Okla. 1913
30. The Pennsylvania State College, State College, Pa. 1914
31. University of Pennsylvania, Philadelphia, Pa. 1914
32. University of Pittsburgh, Pittsburgh, Pa. 1913
33. Princeton University, Princeton, N. J. 1914
34. Purdue University, LaFayette, Ind. 1915
35. Rhode Island State College, Kingston, R. I. 1913
36. Rutgers College, New Brunswick, N. J. 1914
37. University of South Carolina, Columbia, S. C. 1914
38. Stevens Institute of Technology, Hoboken, N. J. 1913
39. Syracuse University, Syracuse, N. Y. 1913
40. The Temple University, Philadelphia, Pa. 1914
41. Throop College of Technology, Pasadena, Calif. 1913
42. Tufts College, Tufts College, Mass. 1914
43. U. S. Naval Academy, Annapolis, Md. 1913
44. University of Utah State School of Mines, Salt Lake City, Utah 1914
45. Vanderbilt University, Nashville, Tenn. 1914
46. University of Virginia, University, Va. 1915
47. Washington University, St. Louis, Mo. 1914
48. University of Washington, Seattle, Wash. 1913
49. University of Wisconsin, Madison, Wis. 1914
50. Worcester Polytechnic Institute, Worcester, Mass. 1913

* Elected at Ames meeting.
† Resigned.

The status of the institutional members was not established until 1913, or twenty-one years after the founding of the Society in 1892. During the year 1913, twenty-two institutions in this country at which instruction in engineering is offered were elected to such membership. During the year 1914, twenty-four institutional members were added, and during the year 1915, four more institutional members were added.

The institutional members and other institutions represented by official delegates at the Ames meeting, and the names of these delegates, are as follows:

Institution.	Delegates.
1. Municipal University of Akron, Akron, O.	Fred E. Ayer
2. University of California, Berkeley, Calif.	C. L. Cory
3. Carnegie Institute of Technology, Pittsburgh, Pa.	J. H. Leete
4. Case School of Applied Science, Cleveland, O.	C. S. Howe
5. University of Colorado, Boulder, Colo.	M. S. Ketchum
6. Cornell University, Ithaca, N. Y.	C. L. Crandall
7. Iowa State College, Ames, Ia.	S. W. Beyer
8. Kansas State Agricultural College, Manhattan, Kan.	A. A. Potter
9. University of Kansas, Lawrence, Kan.	P. F. Walker
10. University of Michigan, Ann Arbor, Mich.	J. F. Wilson
11. University of Missouri, Columbia, Mo.	F. P. Spalding
12. University of Nebraska, Lincoln, Neb.	O. V. P. Stout
13. University of North Dakota, Grand Forks, N. D.	C. H. Crouch
14. Northwestern University, Evanston, Ill.	J. F. Hayford
15. University of Pittsburgh, Pittsburgh, Pa.	F. L. Bishop
16. Rutgers College, New Brunswick, N. J.	H. N. Lendall
17. Tufts College, Tufts College, Mass.	G. C. Anthony
18. University of Utah, Salt Lake City, Utah	J. F. Merrill
19. University of Virginia, University, Va.	W. S. Rodman
20. University of Washington, Seattle, Wash.	F. E. Turneaure
21. University of Wisconsin, Madison, Wis.	C. E. Magnusson

Of the twenty-one institutions named above, nineteen are institutional members. The remaining two, although not institutional members, were represented officially at the meeting by delegates appointed and approved in each instance by the administration of the different institutions. These two institutions are as follows:

1. University of Colorado
2. Northwestern University

Professor C. R. Richards, Acting Dean of the College of Engineering and Acting Director of the Experiment Station, University of Illinois, was chairman of all of the meetings of the institutional delegates, although the University of Illinois is not an institutional member.

Prof. Richards has had much to do in the past in establishing the general plan of institutional membership in the Society, and the service he has rendered in this connection and his intimate knowledge of the aims and ideals centered around the scheme of the institutional membership plan made his selection as Chairman particularly fitting and especially desirable.

Three meetings were held by the institutional delegates, at each of which subjects relating to the best interests of the Society were discussed. The most important session was given over to the discussion of the question "What Can Each Institutional Delegate do to Further the Interest in and Effectiveness of the Society in the Institution Represented by Him?" It was unanimously agreed that institutional delegates should accept their appointment as a definite responsibility rather than merely a personal opportunity and privilege. It was also pointedly suggested that such delegates should, insofar as possible, submit to the Council from time to time papers for presentation at the annual meeting of the Society, dealing primarily with the general and important problems in connection with engineering education.

Finally, each delegate was instructed that he should consider it his especial duty to interest all of the members of the staff of instruction of the institution represented by him, who give courses which form a part of the curricula of the colleges of engineering, in the Society, to the end that its membership may not only be increased in numbers but in breadth of educational interest and a sincere desire on the part of each member to further the important work of engineering education.

Among the papers which were presented at the regular ses-

sions of the meeting, I was personally impressed particularly with the following:

1. The preliminary report of Dr. C. R. Mann, of the Carnegie Foundation for the Advancement of Teaching; speaking for the Joint Committee on Engineering Education.
2. The Address of President Anson Marston at the Annual Dinner. The subject of his address might be said to be: "The Education of the Engineer and His Best Service to Society."
3. "Shop Work as a Part of Engineering Instruction," by B. W. Benedict, Director of Shop Laboratories, University of Illinois.
4. "The Teaching of Analytic Mechanics," by William Kent, Consulting Engineer, Montclair, N. J., and E. R. Maurer, Professor of Mechanics, University of Wisconsin.

The report of Dr. Mann, while of a preliminary character and based primarily upon the replies to certain questions formulated by the Committee received from some four thousand employers of graduates of engineering colleges, set forth without any qualification whatsoever that graduates of our engineering colleges who have the ambition to become engineers are rarely able to correctly and forcibly, either orally or in writing, use the English language in expressing their ideas, no matter how important or valuable these ideas may be.

It was further brought out that for the most part the majority of engineering graduates are primarily interested in, or more often have been given instruction in, courses relating to narrow specialties rather than in broad fundamental subjects.

For these reasons it would seem to be the consensus of opinion of the majority of employers of engineering graduates that the training of such graduates in their college courses for some reason has not produced sufficient mental training and reasoning ability, the breadth of view of many such gradu-

ates being much restricted, and as a result their value to society, measured in any units, decidedly lessened.

Dr. Mann makes a plea to engineering educators to always keep before the students the human, social, economic and also the financial side of life, and to develop as much as possible clear thinking, reasoning, forceful, human men capable of giving expression to their ideas, rather than to produce human machines who depend very largely on slide rules, mathematical and other tables, formulas and hand-books to do the only kind of things of which they seem capable, namely, strictly routine technical work.

The presidential address of Dean Marston, in a most effective manner, supplemented the report of Dr. Mann, and seemed to especially crystallize the general spirit of the meeting.

In my opinion every student, graduate and teacher of engineering, as well as the officials of administration in our American universities, may with great profit read and most seriously consider the important points brought out in Dean Marston's address.

Shop work as a desirable course in an engineering curriculum, according to Director Benedict of the University of Illinois, has no real reason to be continued if it is limited to manual training and the development of skill in the use of tools by the students.

For the past two or three years in the shop laboratories of the above institution, students have been trained in the economic management and administration of manufacturing industries in addition to being made familiar with the processes of pattern making, wood work, forge and foundry work and machine work in iron.

The equipment required and the expense involved in such shop laboratories are of course much greater than is the case in the shops as they have been formerly operated, but the results, according to Director Benedict, not only more than justify the additional expense in the equipment and the operation of such shops, but indicate that unless a different method

of instruction is carried out, it is questionable whether machine shop courses should be continued as a part of engineering courses of a university grade.

The Committee on Mechanics presented its report through Professor E. R. Maurer, of the University of Wisconsin, in the form of a syllabus of dynamics for students of engineering who understand the simpler elements of calculus. This syllabus was manifolded and consisted of 93 mimeographed typewritten pages, a complete copy of which was placed in the hands of each member in attendance at the meeting. A much more brief syllabus of dynamics was proposed by William Kent, this also being manifolded and placed at the disposal of the members of the Society. The discussion of this report is of course of particular value to those members of the instruction staff of our engineering colleges in charge of the work in analytic or engineering mechanics.

Respectfully submitted,

C. L. Cory.

REPORT OF AN INSTITUTIONAL DELEGATE.

BY O. V. P. STOUT,

CHANCELLOR S. AVERY,

Dear Sir: On June 22, 23, 24, 25, I attended at Ames Iowa, the 1915 annual convention of the Society for the Promotion of Engineering Education. Credentials from you admitted me as an institutional delegate. The Society expects that each such delegate, except those who are themselves heads of institutions, submit a report after the meeting to the head of his institution.

Although I have been a member of the Society almost since its inception in 1893, this is the first meeting which I have attended. Consequently, I am unable to compare this with previous conventions. Nevertheless I am led to believe that no other has been of more substantial character nor more completely indicative of results to follow.

It is gratifying, as an engineering instructor speaking of a body made up of men in that line, to be able to say that in all of the papers and discussions practically nothing was said that was not entitled to respectful attention and consideration. There was no "hot air," and I am proud that I "belong." In view of the serious temper of the meeting, and the spirit of service which pervaded, I believe that the already long name of the Society would have to be extended in order to make it completely descriptive. It is manifestly in fact a Society for the Promotion of Soundness and Efficiency in Engineering Education. I make bold to say that the obligation rests on institutions as well as on faculty members to avail themselves to the full of the benefits of association with the Society.

One principle which it seems will be observed in the work of the ensuing year and in preparation for the next convention is the emphasis which will be put upon committee work as dis-

tinguished from papers by individuals. General supervision is in the hands of a committee on committees. The newly elected president, Professor Henry S. Jacoby, of Cornell University, is expected to make his impress on the year's work. He has been active in the American Railway Engineering Association, which is responsible for some of the most effective work done by any American technical society.

Dean C. R. Richards, of Illinois, as first vice-president of the Society, presided at the meetings of institutional delegates. The chief item of business transacted in those meetings was the formulation (by a committee of which I was a member) of a plan of organization and work for the institutional delegates. This plan was recommended to and adopted by the Society.

Professor Chatburn, who has been a member of the Council for the last three years, was elected first vice-president for the ensuing year. As such he is Chairman of the Institutional Committee.

In addition to my membership on the Institutional Committee, I have been unofficially informed that I am a member of the Committee on Administration.

Other faculty members who attended from Nebraska, were Messrs. Hoffman, Ferguson, Raber, Bridgman, Slaymaker and Hollister.

As you doubtless know, the Carnegie Foundation for the Advancement of Teaching, in coöperation with a joint committee of the National Engineering Societies, is conducting an investigation of engineering education in this country. Dr. C. R. Mann, who is in charge of the work, was present at the convention. From his outline of the work, it appears entirely free from features to which any of the institutions might object, and is apparently entitled to our hearty support. He presented also some interesing data developed by the investigation thus far.

Respectfully submitted,

O. V. P. Stout.